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ILIMAGAZINE

EDITION 20

> INTERVIEW HELLEN VAN DER PLAS, CEO BENELUX AT SIGNIFY
> NEW MASTERPLUS PROGRAMME OPTICS & PHOTONICS
> PERCEPTION OF GHOSTING IN LED LIGHTING
> LIGHTCAP PROGRAM COMES TO AN END

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Content

ILI Magazine is a biannual edition of ILI for ILI members, colleagues, collaboration partners, policy makers and related companies - ILI Magazine Spring edition 2024 is published in May

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Enjoy our new magazine!
Harold Weffers
Operational manager

ILI
INTELLIGENT LIGHTING INSTITUTE
TU/e

HAROLD WEFFERS | OPERATIONAL MANAGER

Welcome

With this new edition of our ILI Magazine, we reached a festive milestone as it is the 20th edition of our ILI Magazine. Since its first edition 10 years ago much has happened and many of the exciting and promising developments related to our people, our projects, our facilities and infrastructures and their impact in terms of scientific discoveries & (technological) innovations related to Light and Lighting for various application domains and their societal impact, have found their way into one of the editions of the ILI Magazine.

Also in this festive edition we have many exciting and promising developments to share with you. Amongst others, you will be informed about plans for broadening the scope of ILI as well as the IEEE Sustainable Smart Lighting conference we areco-organizing in November of this year.

Pleasant reading!

MAY 2024 - NOVEMBER 2024

Calendar

15-16 May 2024 LIGHTCAP Symposium
The invisible workings of light, Ketelhuis Eindhoven
lightcap@tue.nl

20 May 2024 Illumination revelations, K. Doerschner, Justus Liebig (Universitat Giessen, Germany) and Sylvia Pont, TU Delft. *Previously seen at Highlight Delft*

12 Nov 2024 ILIAD 2024, Holiday Inn, Eindhoven

12-14 Nov 2024 IEEE Sustainable Smart Lighting Conference 2024, Holiday Inn, Eindhoven

First ILI Magazine


Ingrid Heynderickx, Scientific Director

INGRID HEYNDERICKX | SCIENTIFIC MANAGER

ILI's extending scope

This is the 20th edition of ILI Magazine. ILI started as a TU/e institute that combined expertise of multiple TU/e departments to create the potential to solve scientific and technological challenges for and with the lighting industry. At that moment in time, Philips Lighting (currently Signify) was the main player in the Dutch lighting industry, justifying a very close link between the research programs of ILI and the company strategy of Philips Lighting.

Meanwhile, ILI has extended its scope, and it has grown into a more externally oriented institute. Its original program lines have matured with financial and strategic input of partners from a broader lighting ecosystem. Obviously, Signify is still a key partner in that network, and therefore ILI remains keeping a close eye on the strategy of this company, presented in this magazine by Hellen van der Plas, CEO of Signify Benelux. Yet the recent collaboration with the lighting-oriented academic groups of TU Delft and KU Leuven and their related network have extended ILI's research portfolio and scope.

This year the International SSL Alliance has contacted ILI to organize the yearly international conference on Sustainable Smart Lighting. Hosting this conference is not only a sign of recognition of the impact ILI has in the scientific world of lighting research but can also be considered as a next step in ILI's journey toward a more (inter)national lighting institute. The conference will be attended by about 100 scientists, working in the areas of lighting sources, lighting systems, and smart lighting to the benefit of living species. The conference will be preceded by a half-day program, in which ILI will take the opportunity to present highlights of its current research program in line with ILI's vision on the future of lighting to a broader international public. We hope this will lead to a further extension of our network of collaborations, such that we can also further increase our impact on industrial and societal challenges in the area of lighting. We hope to see you all there.

INTERVIEW | HELLEN VAN DER PLAS, CEO OF BENELUX AT SIGNIFY

By Michiel de Boer (MOESASJI)

Challenging each other in development

Photo Maarten Coolen

"LED technology is far from reaching its pinnacle. There's no successor yet, and there's still a lot of room for development in LED technology," says Hellen van der Plas, CEO of Benelux at Signify. A brief overview of the developments at Signify and collaboration with ILI.

"In reality, we are still in transition. Recently, during a debate in the Dutch Parliament, I saw an LED lamp being discussed. The argument was made that we should switch to this much more energy-efficient technology. Ten years ago, our portfolio consisted of 95% conventional lamps, but now, 85% of it is made up of LED products. While many people and organizations still need to make the switch, we are engaging in discussions that go much further. LED technology is far from finished; there's still so much we can do to make lighting better and smarter."

SUSTAINABLE AND SMART

As a global leader in lighting, Signify is rapidly advancing. The company spends around 5% of its revenue on R&D. Signify's mission is to 'unlock the extra-ordinary potential of light for brighter lives and a better world.' Hellen says, "Sustainability is an absolute priority in our development. We are working on this in many ways. For example, making lighting systems circular. We design circular solutions where almost all components are reusable. Signify remains the owner of the system and ensures everything works correctly or gets a second life, while users only pay for usage. We also experiment with 3D-printed fixtures and other parts that can be customized locally and personally. These are ways to significantly reduce waste and energy."

Another major pillar in development is smarter use of light. Hellen says, "We are constantly discovering what we can do with light and lighting. Driven by network congestion, we need to be smarter and more energy efficient. We don't do this alone; we work with more than 100 partners worldwide, with ILI being by far our largest and most important knowledge partner. When I talk about smart applications, think of adaptive lighting for public spaces, human-centric lighting focused on safety, wellbeing, and productivity. One of our recent developments is LiFi (Light Fidelity), an alternative for wireless communication. This is not about lighting, but it uses light as a medium. LiFi is advantageous because it is incredibly fast, utilizes the existing ubiquitous lighting grid, and works super-locally (on the scale of a workspace), making it very secure.

AWARENESS

However, we are just at the beginning of smart lighting applications. The combination of light with connectivity and data will bring applications we can hardly imagine now. In Horticulture or City Farming, we are developing efficient lighting systems for growing healthy and productive crops, regardless of outside conditions. But there's still much to discover in light recipes. What is the optimal setting for growth, productivity, and the accumulation of as many valuable nutrients as possible? And you want to go even further. If the stores are still stocked with lettuce, you want to be able to adjust the recipe, so the new plants are harvest-ready a few days later, preventing waste. Data is crucial in these develop-ments. And also, environmental awareness: what's happening in the world around us? At Signify, we still have work to do. Technicians can develop incredibly cool things. But we also have a business to run. Sometimes, you have to leave those extra features, even more possibilities, for what they are. The world doesn't benefit from systems that can do 130% if you're only using 80%. Developers must master the technology, but also listen closely to societal needs. >>>

'STREET SMART' DEVELOPMENT

I see it as an incredibly interesting opportunity to further explore this role with ILI. We know each other well, together we do many research projects, PhDs, internships, and validation studies. Technically, we're in a good place. If we can even improve on connecting the inside with the outside, powerful propositions can emerge. This competency is also called upon in European funding projects. We regularly join forces to submit R&D proposals and generate resources for new research. We do this very successfully. We could further strengthen the link between our organizations a bit more when it comes to 'street smart' research and education. Hence, next to organizing interactions between super technicians, to facilitate meetings with commercial competencies as well. We should continue to challenge each other in meeting societal needs. Therefore, we will increasingly touch on adjacent fields of knowledge, such as battery technology, solar energy, connectivity, data analysis, psychology, and so on. There's still so much to discover. Signify and ILI have plenty to do for the foreseeable future. We are very much looking forward to continue the successful cooperation." ■

ILI PhD Theses

Sachin Bhardwaj (Mathematics and Computer Science), February 2024
"Semantic Interoperability in Smart Spaces"
Supervisors: Johan Lukkien and Tanir Özçelebi (TU/e)

Vì C.E. Kronberg (Mathematics and Computer Science), February 2024 - "Inverse Freeform Reflector Design with a Scattering Surface". Supervisors Wilbert Ijzerman and Jan ten Thije Boonkkamp (TU/e)

Stijn Beuckels (Light&Lighting Lab KU Leuven), April 2024 - "Optical characterization of perceptual surface gloss". Supervisor: Frédéric Leloup (KU Leuven)

Rik Spieringhs (IE&IS TU/e and KU Leuven
May 2024
"Development of a New Road Lighting Concept" - Supervisors: Ingrid Heynderickx (TU/e) and Peter Hanselaer (KU Leuven)

ILI EngD Thesis

Sietse W. de Vries (Built Environment), February 2024 "RADYNVR: a Radiance tool for simulating dynamic natural lighting for VR applications" - Supervisors: Mariëlle Aarts (TU/e) and Adrie de Vries (Signify)

JEAN-PAUL LINNARTZ | LOCAL HOST SSL CONFERENCE

The IEEE Sustainable Smart Lighting comes to Eindhoven

Nov 12-14, during the week of the Glow Light Festival, ILI hosts the Sustainable Smart Lighting Conference. This conference has a long track record and is regarded as a flagship conference in the international lighting community. The Conference will coincide with the ILIAD outreach event of the Intelligent Lighting Institute.

This 19th edition has a broad scope, ranging from light technology, systems, and controls, to the effect of light on living species, to applications, ecosystems, and business models. Light has a profound effect on humans, animals, and plants. This continues to be a highly relevant research area. With ubiquitous connectivity, the collection of vast amounts of data opens new opportunities. In fact, with more than 100 M light points connected, lighting forms the largest Internet of Things and many luminaires have integrated sensors.

In a podcast, the local host Prof Jean-Paul Linnartz, and the chair of the International Program Committee, Prof. Georges Zissis debate how Artificial Intelligence approaches this field fundamentally differently than the traditional controlled lab experiments to derive insights on the effects of light and how lights can be controlled to achieve certain objectives. Anyhow, the step from creating insights into implementing algorithms has its challenges, thus these are interesting topics for a multidisciplinary conference.

All in all, a conference that initially was called "Light Sources" (LS), has not only changed its name to Sustainable Smart Lighting, but the topics have broadened in scope. It receives contributions from more disciplines, such as control and signal processing, sensing, IoT networking, Healthy buildings, AI, optics, and physics, but also for instance from perception and human technology interaction. In November, ILI brings the debate to Eindhoven.

So we invite you to save the dates
12 Nov // ILIAD
12-14 Nov // LS24 conference
19 Jul // Deadline to submit a two page abstract

Follow news on LS24 at SSLEindhoven.com and via linkedin.com/company/sustainable-smart-lighting. ■

PHD RESEARCH | MYRTHA GKAINTATZI MASOUTI (TU/E, BUILDING LIGHTING)

How to measure healthy eye-level office lighting

The wearable sensor measuring light close to eye-level.

For more than two decades light scientists understand that light is not only important for being able to see the environment, but also has a profound influence on our sleep, hormone regulation, alertness, mood and performance.

Most of us have a natural sleep-wake rhythm that is a bit longer than 24 hours. So, if we would spend all our time in a cave separate from the environment we would experience slightly longer days. Natural daylight synchronizes our rhythm with the 24-hour daily cycle. However, being exposed to bright light in the evening disturbs our sleep-wake rhythm and can cause sleep problems. It is therefore important to experience bright light during the morning and dim light during the evening. The colour of light is also important, since research has shown that we are more sensitive to blue-enriched light.

Since we cannot measure the amount of light that reaches our brain, the next best thing is to measure the amount of light that reaches our eyes. Traditionally, we would measure light on a desk surface to make sure that it is bright enough for a person to work. However, this is not sufficient when we are interested in how light affects our health and well-being. In fact, we need to additionally measure light vertically at the eye-level. Recently, experts have started to propose guidelines for a healthy eye-level light dose, and it is likely that future lighting design standards will include them. For applying these guidelines in practice, we need to know where a person's eye-level is, but this changes while people change the orientation of their face.

People who work in offices spend a large part of their day indoors and therefore healthy indoor lighting guidelines are especially important for them. For healthy office lighting design, a typical approach is to measure light for

Figure 1: *View of a participant during the laboratory experiment at the Eindhoven University of Technology.*

Figure 2: *View of a participant during the field experiment at the Workplace Vitality Hub.*

a (static) vertical direction facing a computer screen, assuming that the office workers look at their computer screen the entire day. Obviously, people are not staring at their screen all day, but they can look towards a window or towards their colleagues. Looking towards the window, for example, might give them much more light compared to looking towards the computer screen. Therefore, we need to perform studies that compare true eye-level light of people working in offices with static vertical light measurements towards a computer screen.

We performed two experiments to understand how well these static vertical light measurements correspond to true eye-level light received by office workers, while they naturally change their posture and orientation of their face. First, we recreated a single-user office environment in our laboratory at the Eindhoven University of Technology *[Figure 1]*. Second, we conducted a follow-up field study in a real open-plan office environment. With the second experiment we wanted to see if the findings of the first experiment would hold in a more realistic situation. The open-plan office was part of the Workplace Vitality Hub living lab located in the High Tech Campus of Eindhoven *[Figure 2]*. In both the lab and the field experiment, we measured simultaneously static vertical light towards a computer screen and true eye-level light by a sensor on a participant's forehead, which included daylight from the windows, light from overhead luminaires and light from the computer screen *[See main photo]*.

Field studies create rich data, essential for determining realistic eye-level light conditions. However, they have many complexities and we need to be careful if we want to have reliable results. Lightweight wearable light sensors are necessary for field studies, because they need to be easily attached on a participant's clothing or close to their eyes without being too obtrusive. However, the accuracy of this kind of sensors is often questionable. It is necessary to carefully test them and calibrate them before using them in a field study. But even after calibration, inaccuracies might remain. Because of this, it is important to realize that small differences in light measurements between compared conditions might be caused by the inaccuracy of the sensors.

For our experiments, we decided to combine the wearable light sensor measurements with computer simulations in order to reach more reliable conclusions. We measured the participants' face orientation throughout the experiment (i.e., the direction towards which the face of a participant was oriented, e.g., the computer screen or the window direction) using a video processing tool. These face orientations were mapped in a lighting simulation model of the office space. This means that we simulated the light that reached a person's eyes while that person was naturally rotating their face. This method seems to be a reasonable way to get a person's eye-level light when accurate wearable light sensors are lacking.

Both methods that we used (the measurement-based and the simulation-based) showed that, during the laboratory experiment, true eye-level light was approximately 4-10% larger than vertical light measured statically towards the computer screen. The office workers mostly looked towards the central direction of the computer screen and 15 degrees around it. Our initial analysis of the field experiment data confirms this result, but we are still working on more detailed analyses.

In conclusion, the results of the two experiments show that office workers might get slightly more light on their eyes than what is typically assumed, but the difference is very small. Considering that both measurements and simulations have some inaccuracies, we can say that the difference that we found can very well be within an expected error range. This conclusion simplifies healthy office lighting design practice, since it means that including the changing face orientation of office workers is probably not necessary. In the future we will look into the effect of changing position within and outside the office. ■

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

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Not only industry leaders such as ASML, Signify and Demcon, but also renowned research institutes TNO and Imec are committed to stimulate, and further grow the optics and photonics capabilities in the Netherlands. Novel technologies are brought to the market by university's spin-offs like SMART Photonics, PHIX, LioniX International and EFFECT Photonics. The national ecosystems Optics Netherlands and PhotonDelta coordinate these efforts, fostering a fertile ground for corporate giants, startups and research endeavours. A true hub of innovation in Optics and Photonics. ■

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Lighting Research and Technology

XIANGZHEN KONG | EINDHOVEN UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS
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INGRID HEYNDERICKX | EINDHOVEN UNIVERSITY OF TECHNOLOGY, THE NETHERLANDS

Perception of Ghosting in LED Lighting

Modeling the visibility of Ghosting (or Phantom Array Effect)

Have you ever noticed a strange visual effect when driving behind a vehicle with LED-based (light-emitting diode) rear lights at night? The rear lights of the vehicles appear as a trail of lights when you make eye movements across them while navigating the road. Or, have you noticed decorative lighting that "repeats" itself when wandering and looking around in the city? This phenomenon, known as the phantom array effect (or ghosting), is defined by CIE (International Commission on Illumination) as "the change in perceived shape or spatial layout of objects, induced by a light stimulus whose luminance or spectral distribution fluctuates with time, for a non-static observer in a static environment."
The term "non-static" here means that the observer moves their eyes by making fast eye movements (i.e., saccades). The phantom array effect results from making saccades over a temporally modulated light source, and it is most easily observed in low-light situations. Some examples are given in *Figure 1*.

>>>

Figure 1. *Illustrations of the phantom array effect in daily environments. (Up) LED headlights of a police car; (Down) Outdoor decorative lighting*

Why does it happen? Modern LED drivers use a technique called Pulse Width Modulation for brightness control, which actually means rapidly turning the LED on and off, while the perceived brightness is then controlled by the proportion of time the LED is on versus off. The nearly instantaneous responses of LEDs to changing currents imply that also the human eye perceives some of these fast modulations, either directly as a type of flicker, or indirectly via the illumination on a moving object (which is referred to as the stroboscopic effect) or via making saccades (as explained for the phantom array effect). These three types of so-called temporal light artifacts (TLAs) are defined and described in more detail in the technical report CIE 249:2022 (CIE, 2022). Meanwhile models that predict the visibility of flicker (i.e., FVM, the Flicker Visibility Measure) and the visibility of the stroboscopic effect (i.e., SVM, the Stroboscopic Visibility Measure) have been developed. They are described in several journal and conference publications and have been widely applied since then. For the phantom array effect, however, no standardized model that predicts the visibility threshold is available yet.

To contribute to developing such a visibility metric, we designed and executed several psychophysical experiments to quantify the visibility of the phantom array effect. The experimental setup used is illustrated in *Figure 2*. All experiments used a two-interval forced-choice (2IFC) task. The observers were instructed to view two sequentially presented stimuli (i.e., a reference stimulus that was driven with a direct current (DC) and a test stimulus that was temporally modulated with a sinusoidal waveform) and indicate in which of the two stimuli the phantom array effect was observed. Doing that rightfully was considered as a "correct response". An adaptive psychophysical procedure was used to change the modulation depth of the sinusoidal waveform in the next stimuli pair based on the correct or incorrect previous response(s) of the participant. The resulting data were used to fit psychometric functions, describing

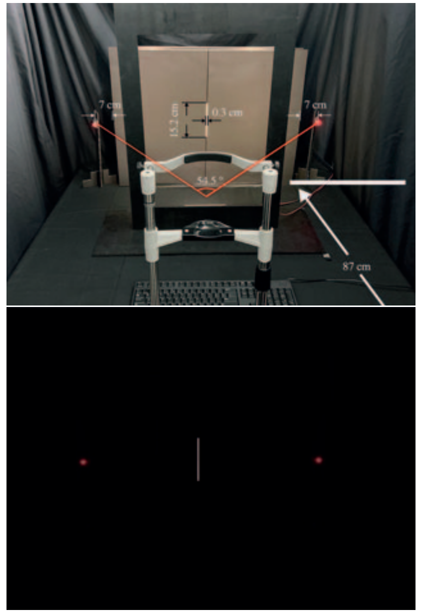

Figure 2. *The experimental setup in the HTI Lab with laboratory light ON (top) and OFF (down)*

the % correct responses as a function of the modulation depth, where one expects 50% (i.e., guessing rate) correct responses of the modulation depth is very small and 100% correct responses when the modulation depth is very large. The visibility threshold of the phantom array effect can then be determined as the modulation at 75% correct responses.

In one of the studies executed at Eindhoven University of Technology, we focused on the effect of temporal frequency and chromaticity of the light source on the visibility of the phantom array effect. The results of this study (see Figure 3) show an inverted U-shaped bandpass sensitivity function for the phantom array effect as a function of temporal frequency for all three chromaticities (i.e., red, green, and warm white) used in the experiment. The 3rd-order polynomial fit indicates a peak sensitivity at a temporal modulation of 600 Hz in all three cases. This finding is in line with earlier results in the literature. However, the peak we found differs from the provisional

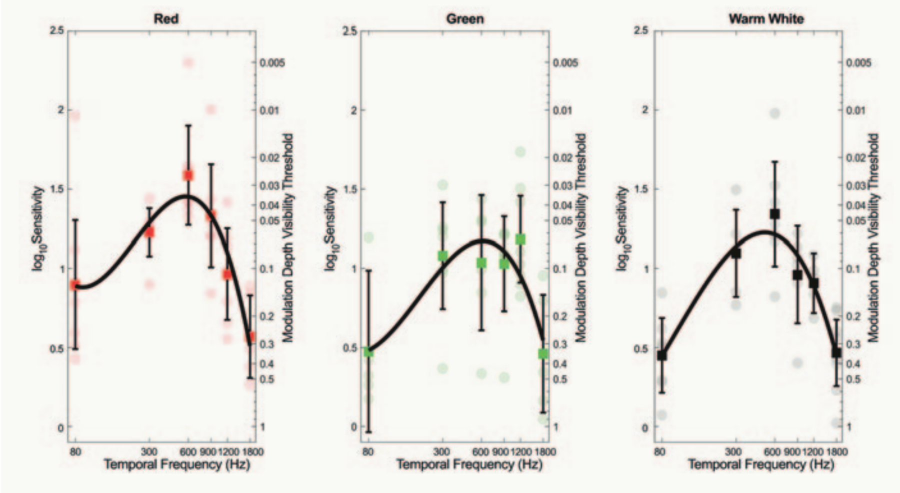

Figure 3. *The sensitivity to the phantom array effect for the three colors. The peak sensitivity is higher for red than for green and white. The MD (Modulation Depth) visibility threshold is about 3% for red and 6-7% for green and white.*

model presented in CIE 249:2022, in which the sensitivity peaks around 1000 Hz. The discrepancy might be due to the different luminance values of the light source.

In addition to those studies executed at TU/e, another experiment was carried out at the Scientific and Technical Centre for Building (CSTB), France. The experiment at CSTB focused on the effect of saccade amplitude and velocity and on the effect of ambient illumination on the visibility of the phantom array effect. All combined data will be analyzed and modeled following the recommendations in CIE249:2022. All experiments so far were carried out in well-controlled laboratory settings and needed to be validated. As such, an additional experiment was designed and carried out at RISE Research Institutes of Sweden. The experiment at RISE used real rear lights from car manufacturers as the light source and will be used to validate the model based on the lab studies. Currently, we are working on the first steps to model the sensitivity curve by taking into account all our findings and existing knowledge. We will carefully evaluate and compare other fitting functions in the coming modeling efforts. Once this sensitivity curve is validated, it can be used by the CIE for standardization. Industry will greatly benefit from this as it enables the design of high-quality lighting systems.

Acknowledgments

The studies were executed within the MetTLM project (i.e., Metrology for Temporal Light Modulation; 20NRM01) and received funding from the EMPIR (European Metrology Programme for Innovation and Research) program co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation program.

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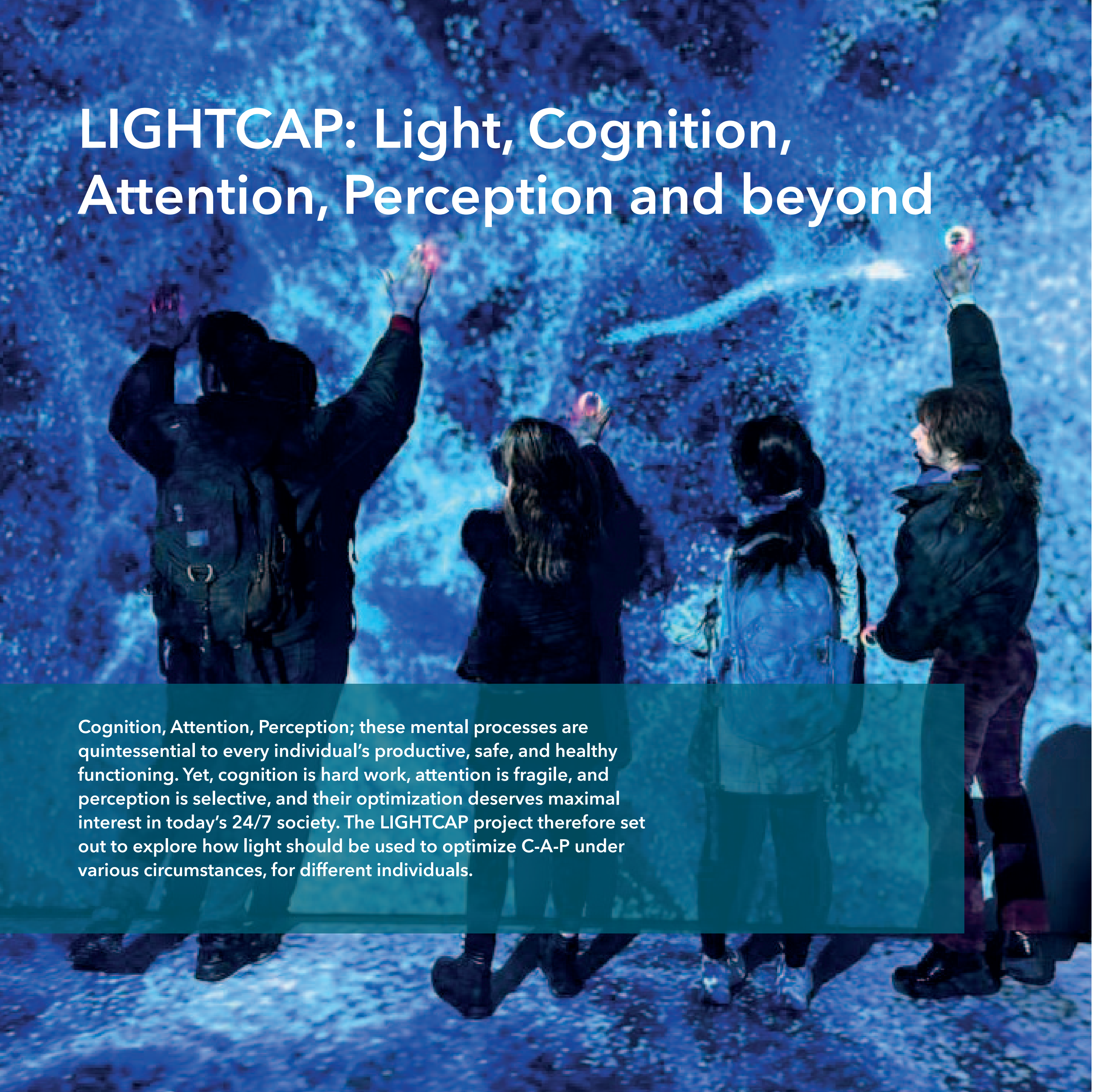


LIGHTCAP: Light, Cognition, Attention, Perception and beyond

Cognition, Attention, Perception; these mental processes are quintessential to every individual's productive, safe, and healthy functioning. Yet, cognition is hard work, attention is fragile, and perception is selective, and their optimization deserves maximal interest in today's 24/7 society. The LIGHTCAP project therefore set out to explore how light should be used to optimize C-A-P under various circumstances, for different individuals.

YVONNE DE KORT | TU/E PROFESSOR HTI GROUP (IE&IS)
Also on behalf of Richard, Vaida, Myrta, Elif, Mariëlle, Juliëtte, Karin, Antal, Luc and Berend

AN INTERNATIONAL, INTERDISCIPLINARY RESEARCH PROJECT COMES TO A CLOSE

We brought together 15 PhD candidates, working in eight labs at seven different universities in five European countries. Our consortium was unique in its approach to non-imaging of light (NIF) from different perspectives: architectural, animal and human biological, ecological and neuropsychological. In the past four years, these early stage researchers and their mentors jointly discussed insights on the perception of light, the path-ways it takes in the human brain, and how this affects sleep, alertness, mood, safety and health, but also how it travels through space, how it varies over time and locations, and how, in view of all these perspectives, it should be measured. We shared ideas and learned from each other and about each other's disciplines, methods and challenges. Although the project is formally closing, many PhD projects are still ongoing, so many of our insights to date are still preliminary, as analyses have not been fully finalized. But below I hope to briefly illustrate both the breadth and depth of our investigations.

A BROAD RANGE OF STUDY METHODS

fMRI, EEG and pupil reflex based current preliminary findings provide indications that light can affect cognitive brain function even before it translates into detectable behavioral responses. But of course, we also employed lighting simulations, task performance measures of attention and higher executive functions, physiological indicators (e.g., heart rate variability, skin conductance, melatonin), and subjective reporting ranging from questionnaires and experience sampling to in-depth interviews.

Many investigations of the LIGHTCAP project included manipulations of the characteristics of light to better understand its mechanisms of action. In particular, determining which photoreceptor is the main driver of the multiple impacts of light is an important step towards understanding the way that light interacts with the brain. LIGHTCAP studies investigated spectral tuning (including silent substitution), dose-response relationships, prior light history as well as the spatial distribution of light. The results of one such study for instance suggest that light from the upper part of the visual field is more effective in reducing subjective sleepiness and improving reaction time performance.

YOUNG AND OLD, HEALTH AND DISEASE, DAY AND NIGHT, INDOOR AND OUTDOOR

LIGHTCAP explored individual differences, in particular related to age, with attention for both teenagers and seniors. Moreover, we explored the multifaceted

The Invisible Workings of Light

Interactive symposium on light's effect on humans for researchers, industry and architects

15 & 16 May 2024, Het Ketelhuis Eindhoven

relationships between light and health but also between light and diseases, when we investigated the impact of light exposure on retinal and brain impairment (Alzheimer's in particular) and on residual daytime complaints of persons with chronic sleep disorders. For the general population, we not only investigated effects of daytime usage of light (in schools, offices, nursing homes), but also nighttime effects. An important theme pertained to lighting in outdoor environments and its impact on safety - both in terms of the feeling of safety (e.g., walking alone at night) and "objective" safety (e.g. preventing accidents while driving or falls while walking). One potential mechanism behind the general feeling of safety or safety perception is related to anxiety. It appears that anxiety level will predominantly define how light can influence the feeling of safety in outdoor situations.

TOOLS FOR PRACTICE

Within LIGHTCAP we also worked on better tools for researchers and designers. For instance, we explored new and better ways to measure and quantify light exposure in real-life conditions. Moreover, we further developed an open-access tool that assists architects and lighting designers to predict the amount of light, as well as the spectral content and the spatial distribution of light (Lark Spectral Lighting 2.0). The tool allows for the simulation of amount of daylight and electric light indoors with a nine-band spectral resolution over a period of time.

DISSEMINATION

Studies are key to our current understanding of the mechanism through which light impacts humans across the lifespan and the more we learn, the better we will be able to translate our insights into applications. LIGHTCAP work will be (and has been) disseminated via scientific articles, conferences and websites of course, but for those curious to learn more: all PhD candidates and their mentors will be presenting their findings and sharing their insights at the LIGHTCAP closing event, May 15-16 in Eindhoven. You are warmly invited to join and reflect with us on implications and new ambitions! ■

ILI SHORT

NWO awards funding to research project Martijn Anthonissen

The Dutch Research Council (NWO) recently announced which proposals were awarded funding under its Open Technology Program 2024. The program offers companies and other organizations an accessible way to participate in scientific research that is intended to lead to societal and scientific impact.

One of the awarded programs is the project of Martijn Anthonissen, Assistant Professor and working in the Computational Illumination Optics group at the Department of Mathematics and Computer Science. With his project, Anthonissen aims to look for a way to combat light pollution. The NWO awarded his pioneering work a grant of 600,000 euros.

The Netherlands with its high population density has a very high level of light pollution: the excessive lighting of the environment at night, using artificial light. If you look at our country from outer space, you can immediately see that the Netherlands is one of the most illuminated countries in the world. While light in the darkness can provide a certain sense of security, there are also significant drawbacks to excessive use of artificial light: It disrupts our sleep rhythm and kicks nature's biorhythms into disarray.

The Computational Illumination Optics research group is fully committed to exploring alternative ways to illuminate our cities. That is why Anthonissen emphasizes that winning the funding would not have been possible without Full Professor Wilbert IJzerman and Associate Professor Jan ten Thije Boonkkamp: their contribution was essential to come up with a rock-solid proposal.

Anthonissen's project is based on the principle that lighting works with mirrors and reflection. He aims to use mathematics to adjust the convexity or surface area of lenses in such a way that light can be directed in a much more focused manner than before. This can significantly reduce light pollution and glare. Thanks to the grant, Anthonissen can appoint two additional doctoral students. They will do four years of research each as part of the project.

By Martijn Luyk, (Mathematics and Computer Science TU/e)

LIEKE DIEDEREN | PR MANAGER IGNITE

Team IGNITE: **International inspiration**

As Team IGNITE, a student-led light design studio, we've dedicated ourselves to showcasing the transformative power of light for the last couple of years. While our journey began in Eindhoven, primarily exhibiting at the renowned GLOW Eindhoven light festival with 1-3 projects annually, we've now set our sights on broader horizons, aiming to unite people worldwide through the medium of light. Where the city of Eindhoven allowed us to make an impact locally and start small in a familiar environment, we are now trying to look beyond.

But to get there we recognized the need to expand our knowledge and network, as well as to professionalize our craft. We wanted to learn from professionals and other artists, learn about other places, and learn where to find these new chances. Working together with the Intelligent Lighting Institute, one of our most valuable partners, we gained access to the international light community, including the Lighting Urban Community International (LUCI).

The first steps we have taken in that direction led us to European light festivals and conferences where artists, designers, and professionals in the light industry come together. Starting at the Luci d'Artista festival and conference on Light Art in Public Spaces in Turin to the Fête des Lumières and LUCI conference in Lyon, where during the winter period, the cities transformed into an open-air museum of light installations by great local and international artists.
These experiences challenged us to rethink our approach, emphasizing the importance of inclusivity, permanence, and public space in our projects. We learned more about the power of light art as a medium for sparking meaningful conversations and fostering connections and inclusion within communities. It inspired us to look at our previous projects in a new light and inspired us to start our upcoming projects with new, and bigger, goals. Goals such as looking at more permanent implementation of our artworks as light art is becoming more and more permanent in the city, but also to use our art pieces as a conversation starter, as a social medium.

And very importantly, we learned more about our strengths and our position in this field. As a team of ambitious students, we have always been committed to pushing boundaries and breaking down barriers by interconnecting diverse disciplines within our team to maximize our impact. So we will continue to look for ways to improve, to innovate, and to explore even further; not just in the quality or scale of our projects, but also to see what we can achieve with these artworks outside of our typical city of Eindhoven. Who knows where you will find us and our creations in the upcoming years?

Join us as we strive to unite people and make a difference–one light at a time. ■

PHD RESEARCH | SACHIN BHARDWAJ (TU/E MATHEMATICS AND COMPUTER SCIENCE, INTERCONNECTED RESOURCE-AWARE INTELLIGENT SYSTEMS)
SUPERVISORS | JOHAN LUKKIEN AND TANIR ÖZÇELEBI

Semantic interoperability in smart spaces: Intelligent lighting use case

My Ph.D. thesis titled "Semantic Interoperability in Smart Spaces" was supported by the European project called SOFIA, which stands for Smart Objects for Intelligent Applications. Smart spaces are physical environments enabled by technology to make life easier and more comfortable. Their potential to enhance people's living standards is now widely investigated through real-world implementations. These spaces consist of embedded devices with various hardware, software, and communication platforms. To perform optimally, they require information exchange and interoperability among their embedded devices and services. However, embedded devices in smart spaces vary in terms of their sensing, actuation, and control capabilities, as well as their processing, storage, and networking resources. As a result, there is a need "to create a semantic interoperability platform and selected set of applications to form an embedded system based smart environment," which was also the ultimate mission of the SOFIA project. In my thesis, as a solution to semantic interoperability needs of intelligent lighting, we developed a comprehensive semantic interoperability architecture and put it to test in various intelligent lighting use cases. Furthermore, we developed an innovative smart lighting model, enabling continuous monitoring and control of illumination in an activity space through sensing and actuation.

SEMANTIC INTEROPERABILITY IN SMART SPACES

Smart spaces encompass a wide spectrum, ranging from buildings equipped with networked temperature and motion sensors to vehicles that continuously relay their location, performance, and maintenance requirements. They offer significant benefits, particularly for the environment, by reducing energy costs through real-time adjustments of heating, cooling, and lighting based on changes in weather and occupancy. With remote monitoring and adjustment capabilities, smart spaces not only diminish carbon footprints but also save money in the process. Additionally, they play a crucial role in averting hazardous situations; the monitoring and remote control features enable supervisors to detect and often prevent problems before they escalate. Given their potential to enhance people's living standards, intensive research is underway to explore real-life applications of smart spaces. The effectiveness of a smart space largely hinges on the level of interoperability and collaboration among its various components, also known as 'smart nodes.' Supporting interoperability is essential in designing smart space architectures. The ability to convey meaningful information (semantics) across nodes and establish a shared understanding is known as semantic interoperability. Ultimately, the smart space semantic interoperability architecture developed in this thesis offers solutions to integrate and coordinate smart nodes effectively.

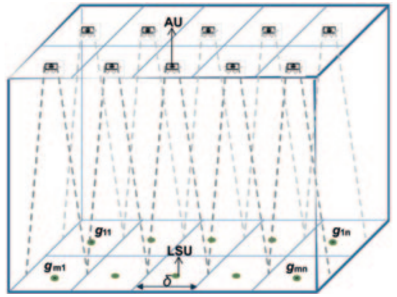


Figure 1: *Smart lighting model indoor space.*

Figure 2: *LED lamps designed for experiments.*

SMART LIGHTING MODEL AND INDOOR APPLICATIONS

The presence of adequate lighting is essential for any task one wishes to undertake. Humans prefer varying levels of illumination for different activities, and they perceive, interact with, and are influenced by lighting in numerous ways. The introduction of smart lighting applications, as a specific type of smart space application, not only enhances the utilization of natural light sources (such as adjusting blinds to regulate exposure to daylight and moonlight) but also offers unprecedented control over artificial lighting. The innovative smart lighting model is engineered for continuous monitoring and control of illumination in an activity space through sensing and actuation. This model serves as the basis for implementing lighting applications using a semantic interoperability architecture. Employing a gateway approach, the model seamlessly integrates resource-poor nodes (e.g., sensors, actuators) into a smart space. The gateway node executes complex tasks on their behalf, facilitating their semantic interactions with each other and with other resource-rich nodes.

SMART SPACE LIFE CYCLES

This investigation into the life cycles of smart spaces aims to assess the practical implications and benefits that the semantic interoperability architecture brings to the overall development and implementation of smart lighting applications. From the perspective of smart space developers, a standard software system life cycle comprises six distinct stages: analysis, design, implementation, testing, deployment, and maintenance. Examining the life cycle perspective of a system provides valuable insights into the tasks associated with each stage, the stakeholders responsible for and impacted by these tasks, and the challenges that may arise. In this thesis we focus on a case study involving the implementation of smart lighting applications within smart spaces utilizing the semantic interoperability architecture. The smart (lighting) space life cycle elucidates the process of designing a smart space while incorporating the deployment of the smart lighting model. This life cycle consists of three integral components: the smart node life cycle, the smart service life cycle, and the smart application life cycle. These components offer a holistic view, allowing for an in-depth exploration of each life cycle to provide a comprehensive understanding of their interplay in the context of implementing smart lighting applications. ■

The mystery of blinding headlights

NRC interviewed Ingrid Heynderickx, professor of applied visual perception to gain more insight into how and why.

The annoyance surrounding blinding headlights is growing. The phenomenon, intensified during the winter months, affects not only motorists but also cyclists, and even scooters, highlighting the urgency of the problem. NRC interviewed Ingrid Heynderickx, professor of applied visual perception, among others, to gain more insight into how and why.

The striking increase in complaints, illustrated by a recent ANWB survey with more than 10,000 responses, debunks the misconception that only older people experience this as a problem. Heynderickx explains that modern LED lights, although energy efficient and directional, cause glare due to their point source characteristics. The solution? Heynderickx suggests the use of reflectors in lamp units to disperse light more broadly, a modification that, however, often clashes with car manufacturers' aesthetic priorities. The article sheds fascinating light on the delicate balance between functionality and design in the automotive world.

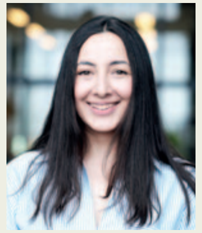
End of October 2024

Dutch Daylight Awards

In 2024 another edition of the Dutch Daylight Awards is scheduled. And a double one; in addition to the well-known Dutch Daylight Awards, a Student Award has also been established this year. Both entries are now open. An expert jury has been assembled and will present itself shortly on the website. They will also soon announce the time and location of the awards. It promises to be another spectacle.

For more information:
https://dutchdaylight.nl/award/

They look forward to receiving your entries before May 15!



Intellight (+) project

At the Eindhoven Engine meeting on 14th March, representatives from four different project groups, all (partly) funded by Eindhoven Engine, were present. *Özge Karaman - Madan* had the opportunity to discuss the current progress of the Intellight (+) project with a focus on the findings from her PhD work. Furthermore, the next steps of her PhD project and possible collaborations with the partners were discussed.

ILI New Employees

LISA KUSCH
Ass. Professor MCS

Hi, I am Lisa Kusch and I joined the Computational Illumination Optics Group at CASA on January 15th of this year as an assistant professor. I studied computational engineering science at RWTH Aachen University in Germany and did my PhD and PostDoc in mathematics at the Scientific Computing Group at RPTU Kaiserslautern.

My research focus is optimization, specifically optimization with multiple objectives, and optimization under uncertainty. A research challenge I like to work on is to combine these topics and formulate and solve problems involving multiple objectives under uncertainty. I enjoy finding solutions to application-driven problems in physics and mechanical engineering. So far, I have worked on projects in the field of fluid mechanics, structural mechanics, and medical imaging.

A new research topic for me is to develop strategies dedicated to minimizing aberrations in imaging optics. I am looking forward to working in the ILI community on problems involving light.

HANGYU LIU
PhD Human Technology Interaction group (IE&IS)

I obtained my Bachelor's degree in Measurement & Control Technology and Instruments from Tianjin University in China. My undergraduate studies were characterized by a deep engagement with engineering principles and advanced technologies.

After completing my Bachelor's degree, I pursued a Master's degree in Mechatronics and Information Technology at the Karlsruhe Institute of Technology (KIT) in Germany. During my master's studies, the COVID-19 pandemic had a significant impact on my research interests. I decided to contribute to the intersection of technology and human health by conducting my Master's thesis on detecting anxiety disorders through non-invasive signals using machine learning techniques.

November 2023, I began my PhD-journey in the Human Technology Interaction group with my supervisors, Dr. K.C.H.J. Smolders and Prof. Dr. Ir. Y.A.W. de Kort. Here, my research focuses on the quantified effects of light on health. Specifically, we aim to enhance the quanti-fication of real-life light exposure patterns and improve the modeling of light-induced modulations in health-related indicators.

KOONDI MITRA
Ass. Professor MCS

"Greetings! I am Koondi Mitra, and I am thrilled to be a part of the Intelligent Lighting Institute. I joined the Computational Illumination Group recently as an assistant professor.

I received both bachelor's and master's degrees in mechanical engineering from India before embarking on my academic journey. Having received a doctorate with cum laude distinction at TU/e, I went through a four-year academic pilgrimage through esteemed institutions across Europe.

My expertise lies in developing robust algorithms, efficient discretization, and adaptive methods for differential equations. I also work on explaining physical phenomena through mathematics and have worked in diverse fields such as multiphase flow, mathematical biology, and wildfires.

I intend to extend my expertise to imaging and non-imaging optics, shedding literally "new light" through mathematics. If you want to understand physical systems at a deeper level as much as me, then feel free to get in touch. Together, let's illuminate the future!"

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