INTEGRATED DAY & ELECTRIC LIGHTING AND SMART CONTROL

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Glare Meter integrating an HDR vision sensor and an Intel Compute Stick for on-the-fly glare and workplane illuminance assessment with WiFi data transmission..

Integrated Day & Electric Lighting and Smart Control research focuses on advanced systems for optimal use of daylight in buildings with the aim to improve user comfort and health and reduce energy consumption. Developments of the group include a scanning sky simulator and an automated heliodon, which allow reproducing with high precision any daylight condition, as well as several anidolic (non-imaging) daylighting systems. Furthermore, it set up a bidirectional transmission goniophotometer based on digital imaging that allows assessing the characteristics of complex fenestration systems. More recently, activities have focused on user-centric lighting, and advanced monitoring devices have been developed both for real-time outdoor and indoor photometric and glare risk monitoring for blind control.

Smart control of façade elements and building services through the use of artificial neural networks, genetic algorithms, fuzzy logic and other advanced optimization algorithms has been another focus of the lab for many years.

Published work relates to

- Circadian rhythms and impact of light in humans, visual comfort
- Daylighting computer design and analysis tools
- Integrated day- and electric lighting systems
- Bidirectional reflection and transmission goniophotometer
- Anidolic daylighting systems
- Experimental and ergonomic daylighting test modules
- High-resolution mapping of the sky and ground vault
- Visual comfort monitoring devices
- Self-adaptive integrated building control systems
- Artificial neural networks for adaptive models and control systems.
- Genetic algorithms for adaptation to user preferences

Activities

A SCCER FEEB&D project proposed automated 'Eyesight' venetian blinds to better foster the utilization of daylight in buildings, overcoming the limitation of existing shadings, including insufficient glare protection, disturbing movement of slats, privacy issues, and commissioning difficulty. The experimental monitoring of this embedded photometric device (EPD) integrated in test beds at EPFL and LBNL showed that it is able to close and re-open shading timely to satisfy occupants' visual satisfaction under different sky conditions. The projected cooling load mitigation is estimated to reach 47% on average in a warm climate, compared with no shading protection.

Thanks to an ENAC Innoseed and an EPFL Innogrant support, the EPD is now moving further toward industrial production. This is also the case of HDR vision sensors issued from the same SCCER in the form of fully autonomous and WiFi connected glaremeters.

Current Projects

SCCER FEEB&D Phase II, Task 1.2.2 Automated "Eyesight" Venetian Blinds
Funding: *Swiss Innovation Agency (Innosuisse)*
Duration: *2017- 2020*
Automation of External Venetian Blinds can enhance occupants' visual comfort and achieve energy savings in electric lighting as well as cooling/heating load. In this task, an integrated 'open-loop' automated system is developed based on a digital camera positioned in the outer part of a window frame that points toward the sky vault. Through image processing and lighting computations, glare risks and luminance distribution in the room are evaluated. The algorithms are implemented in an ultra-fast microprocessor for real-time calculation.

NEST SolAce | REcomfort - Perception based Human Comfort and Multi-Functional Solar Facade
Funding: *ETH Board*
Duration: *2017-2020*
Even in old-established branches like the heating, ventilating and air conditioning industry there are blank areas: one of these spots is the capture of solar energy and daylight by the building envelope. These topics are investigated by EPFL Researchers and their industrial partners in the SolAce | REcomfort unit: multifunctional facade technologies are implemented to achieve an Energy-Plus and Low Carbon combined working/living space.

Safe and Smart Blind and Lighting Control
Funding: *Swiss Innovation Agency (Innosuisse)*
Duration: *2019-2020*
The goal of this project is to develop and validate an innovative control approach incorporating a novel High Dynamic Range vision sensor for glare sensation and light stimulation assessment as well as a wind profile prediction algorithm designed to avoid physical damages to blinds and optimize blind movement with respect to useful solar heat gains in office buildings. Validation includes tests of visual performance, user acceptability and robustness in two sites.

PhD theses

- Wu Y., Advisors: Scartezzini J.-L., Kämpf J. H., Automated Daylighting Control System based on Sky Luminance Monitoring and Lighting Computing, Thèse EPFL, n° 9498, 2019
- Motamed A., Advisor: Scartezzini J.-L., Integrated Daylighting and Artificial Lighting Control based on High Dynamic Range Vision Sensors, EPFL PhD Thesis #8277, 2017
- Maierova L., Lighting Environment in Buildings - Nonvisual Light Perception and Inter-Individual Differences, PhD Thesis Czech Technical University in Prague, Faculty of Civil Engineering, 2015
- Zarkadis N., Advisors: Scartezzini J.-L., Morel N., Novel models towards predictive control of advanced building systems and occupant comfort in buildings, EPFL PhD Thesis #6440, 2015
- Basurto C., Advisors: Scartezzini J.-L., Kämpf J. On advanced daylighting simulations and integrated performance assessment of complex fenestration systems for sunny climates, EPFL PhD Thesis #6425, 2014

Selected publications

- Motamed A., Deschamps L., Scartezzini J.-L., Eight-month experimental study of energy impact of integrated control of sun shading and lighting system based on HDR vision sensor, in Energy and Buildings, vol. 203, p.109443 , 2019 https://doi.org/10.1016/j.enbuild.2019.109443
- Wu Y., Kämpf J. H., Scartezzini J.-L., Performance assessment of the BTDF data compression based on wavelet transforms in daylighting simulation, in Solar Energy, vol. 190, p.329-336 , 2019 https://doi.org/10.1016/j.solener.2019.07.096
- Wu Y., Wang T., Lee E. S., Kämpf J. H., Scartezzini J.-L., Split-pane electrochromic window control based on an embedded photometric device with real-time daylighting computing, in Building and Environment, vol. 161, p.106229 , 2019 https://doi.org/10.1016/j.buildenv.2019.106229
- Wu Y., Kämpf J. H., Scartezzini J.-L., Automated 'Eye-sight' Venetian blinds based on an embedded photometric device with real-time daylighting computing, in Applied Energy, vol. 252, p.113317 , 2019 https://doi.org/10.1016/j.apenergy.2019.113317
- Benedetti M., Maierová L., Cajochen C., Motamed A., Münch M., Scartezzini J.L., Impact of dynamic lighting control on light exposure, visual comfort and alertness in office users, CISBAT 2019, Lausanne, Switzerland, September 4-6, 2019 https://iopscience.iop.org/issue/1742-6596/1343/1

Patents

- Sky monitoring system, WO/2019/030639, Wu Y., Kämpf J.; Scartezzini J.-L., 2019
- Lighting control system, WO2017216623 (A2) Motamed A., Deschamps L., Scartezzini J.-L., 2017