# SMART BUILDINGS / SMART CITIES

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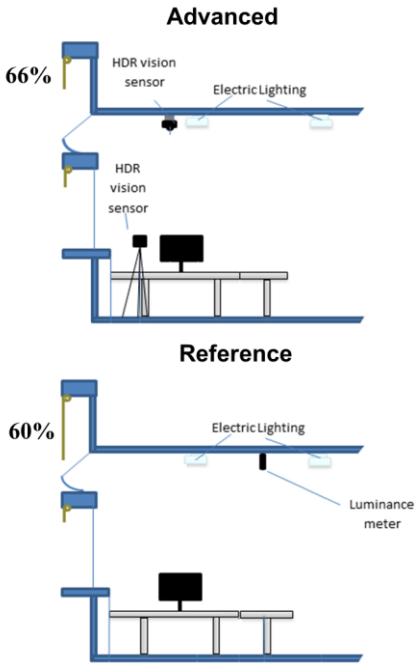


**Average shading opening fraction comparison between reference and advanced office**

Smart control of building services (heating, cooling, ventilation, blinds, electric lighting) can simultaneously optimize energy use and indoor comfort (thermal, visual, air quality) through the use of advanced computer methodologies such as artificial neural networks, genetic algorithms, fuzzy logic, or advanced optimization algorithms. Our laboratory investigates control algorithms allowing at the same time:

- an optimal response to changing conditions (weather, building occupancy, lighting levels, thermal characteristics)
- a progressive adaptation to (possibly changing) building characteristics and to user preferences.

Research projects normally include two steps:

- development of innovative control algorithms and evaluation with computer simulation tools
- testing under real situations and evaluation of energy and comfort performances as well as acceptance by users.

Most smart controllers are evaluated in the LESO building, which represents a powerful tool for this group.

### Published work relates to

- Self-adaptive integrated building control systems
- Blind and electric lighting control algorithms
- Advanced control of electrochromic glazing
- Genetic algorithms for adaptation to user preferences
- Fuzzy logic for implementing building physics expert knowledge into the control algorithms
- Artificial neural networks for adaptive models and various control systems (for instance thermal model of the building or weather evolution).

## 2017 Activities

HDR vision sensors were integrated in a sun shading and electric lighting control platform to measure two photometric variables in a workspace: (i) the Daylight Glare Probability experienced by the user and (ii) the workplane horizontal illuminance. The system was successfully tested against a reference system in the LESO test building as well as in a testbed at Fraunhofer Institute for Solar Energy Systems. Furthermore, the platform was used to assess several energy efficient control approaches. The HDR vision sensors are in the process of further improvement in collaboration with CSEM and Analog Device Inc. (recent buyer of SNAPsensor) to provide similar integrated lighting controllers in daily life in collaboration with industrial partners.

Furthermore, a new project was launched to integrate the non-image-forming effect of light in venetian blind and electric lighting control. A prototype will be integrated in the NEST Test building at EMPA in Dübendorf.

## Current Projects in Smart Buildings

SCCER FEEB&D Phase II, Task 1.2.1 - High Dynamic Range (HDR) Vision Sensing Technology
*Funding: Commission for Technology and Innovation (CTI)*
*Duration: Phase II 2017-2020*

The integration of advanced daylighting systems with high efficacy light sources (LEDs), energy efficient luminaries (based on non-imaging optics) and advanced controllers for HVAC and lighting systems should allow reaching energy self-sufficiency for lighting systems. In Phase I of this project, a high dynamic range (HDR) vision sensor was configured for use in a sun shading and electric lighting control platform, and its suitability for luminance measurements in a working environment as well as for glare risks assessment based on the Daylight Glare Probability was validated. In Phase II, sensing devices will be further refined and adapted to the needs of the lighting and shading industry. The controllers will undergo field testing in diverse testbeds.

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.

## Selected 2017 publications


- Motamed A., Deschamps L., Scartezzini J.-L., On-site monitoring and subjective comfort assessment of a sun shadings and electric lighting controller based on novel High Dynamic Range vision sensors, in Energy and Buildings, vol. 149, p.58-72 , 2017
- Benedetti M., Motamed A., Deschamps L., Scartezzini J.-L., On the integration of Non-Image-Forming effects of light on venetian blinds and electric lighting control, CISBAT 2017 International Conference, Lausanne, Switzerland, 6-8 September 2017, in Energy Procedia - CISBAT 2017 International Conference Future Buildings & Districts - Energy Efficiency from Nano to Urban Scale, p.1039-1044


## Recent PhD theses in this domain

- Integrated Daylighting and Artificial Lighting Control based on High Dynamic Range Vision Sensors, *Ali Motamed, EPFL PhD Thesis #8277, 2017*
- Novel models towards predictive control of advanced building systems and occupant comfort in buildings, *Nikos Zarkadis, EPFL PhD Thesis #6440, 2015*
- Probabilistic Bottom-Up Modelling of Occupancy and Activities to Predict Electricity Demand in Residential Buildings, *Urs Wilke, EPFL PhD Thesis #5673, 2013*
- On the adaptation of building controls to the envelope and the occupants, *David Daum, EPFL PhD Thesis #4935, 2010*
- Towards a unified model of occupants' behaviour and comfort for building energy simulation, Frédéric Haldi, *EPFL PhD Thesis #4935, 2010*
- Bayesian optimisation of visual comfort, *David Lindeloef, EPFL PhD Thesis #3918, 2007*
- Simulating occupant presence and behaviour in buildings, *Jessen Page, EPFL PhD Thesis #3900, 2007*

## Patents

- WO2017216623 (A2) Motamed A., Deschamps L., Scartezzini J.-l., Lighting control system, 2017