Analyzing the changes in captured daylight in real-time videos: Development of new motion detection methods for luminous changes

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Project Type: Semester Project (can be prolonged into a Master project depending on mutual interest and development)

Context

A window lets in natural light from the sun to an indoor environment, which impacts indoor thermal and visual comfort as well as the health and well-being of building occupants. When entering into buildings through windows, daylight reflected from outside becomes the main source of illumination for an indoor environment and carries visual information, which is perceived by building occupants as the view[1]. Therefore, daylight can be defined both as the carrier of an outdoor view as well as the illuminance transmitted through the window[2]. Both view-out and daylight conditions were found to provide numerous health-related benefits, including increased alertness, mood, relaxation, job satisfaction, work productivity, and cognitive performance[3]. Exposure to natural environments and daylight through a high quality view-out, therefore, is critical for building occupants' health and well-being[4].

At the Laboratory for Integrated Performance in Design (LIPID), one of our research goals is to uncover the interrelationship between daylight and view-out based on original data from human subjects. We recently developed a virtual reality (VR) framework for capturing window views using a Canon EOS R5 camera with a dual fisheye lens and a scale model, which collects view-out scenes as real-time videos that can be easily exported to VR environments.

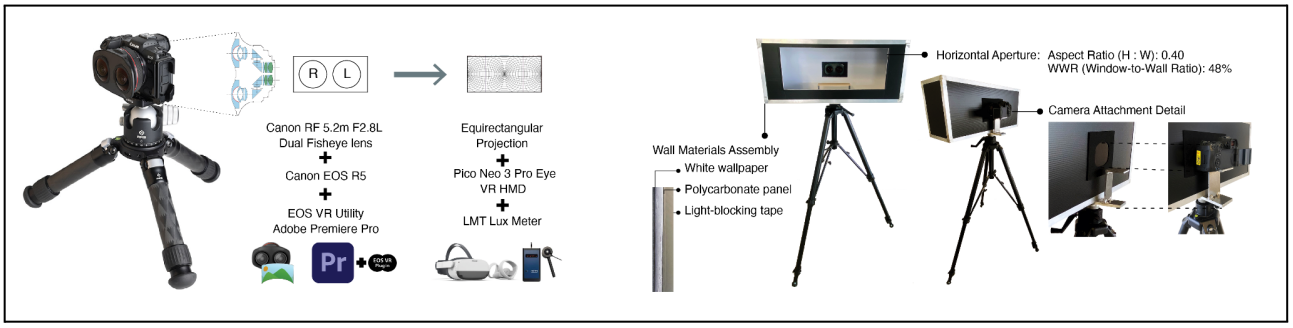

Figure 1. Overview of the equipment used for capturing view-out scenes for VR.

[1] Ko, W. H., Kent, M. G., Schiavon, S., Levitt, B., & Betti, G. (2021). A Window View Quality Assessment Framework. LEUKOS, 1–26.
[2] Abd-Alhamid, F., Kent, M., & Wu, Y. (2022). Quantifying window view quality: A review on view perception assessment and representation methods. Building and Environment, 109742.
[3] Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C.-H., & Zee, P. C. (2014). Impact of Windows and Daylight Exposure on Overall Health and Sleep Quality of Office Workers: A Case-Control Pilot Study. Journal of Clinical Sleep Medicine, 10(06), 603–611.
[4] Lam, W. M. C. (1977). Perception and lighting as formgivers for architecture. Van Nostrand Reinhold New York.

This representation method will be used for future experiments to compare perceived view qualities. We are looking to develop new analysis methods for detecting changes in daylight conditions, similar to the example shown below.

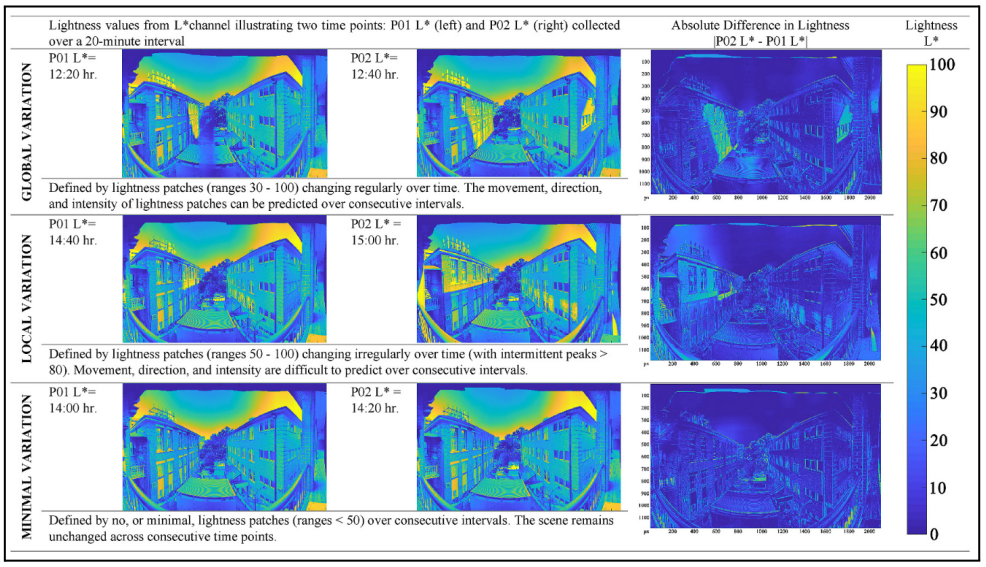

Figure 2: Example representation for capturing changing daylight conditions as done by Rodriguez et al. (2021)[5].

This new detection method will be based on the captured videos from the proposed camera setup through a semester project, focusing on image analysis and correlation techniques for motion detection and tracking.

Objectives

The objective of this project is to develop new methods to analyze changes in daylight conditions for the videos gathered with the new camera setup. The focus is on developing/testing/comparing and implementing methods for:

- detecting temporal changes and motion in video footage
- extracting information about the changes in daylight and sky conditions
- tracking the luminous changes and calculating their speed

All methods should be developed for efficient analysis of large sets of videos and validated in a systematic research and development process. The final project outcome should be a working implementation of the developed methods (ideally in Python), together with a written report documenting the research and development process.

Deliverables

The student will present their development progress and research through:

- A midterm presentation (10 min)
- A final presentation (20 min)
- A written report (accounting for 2/3 of the final grade)

The report and presentations must be in English.

[5] Rodriguez, F., Garcia-Hansen, V., Allan, A., & Isoardi, G. (2021). Testing the adequacy of luminous change descriptors to represent dynamic attributes in outdoor views. Building and Environment, 191, 107591.

Requirements

The project involves the development and implementation of computational methods for image data. Therefore, the student should have a background in image processing and computer vision algorithms, computer science and/or machine learning, and should be proficient in Python. Familiarity with the topic of lighting would be useful but is not mandatory.