Citation: **Maha Anber, Omnia Shawky (2024), Achieving Indoor Thermal Comfort Using AI-Controlled Shading in Hot Arid Climates in Office Buildings, International Design Journal, Vol. 14 No. 6, (November 2024) pp 205-213**

Achieving Indoor Thermal Comfort Using AI-Controlled Shading in Hot Arid Climates in Office Buildings

Maha Anber

Associate Professor, Department of Architecture, Higher Institute of Engineering, El-Shorouk Academy, El-Shorouk City 11937, Egypt, maha.fawzy@sha.edu.eg

Omnia Shawky

Assistant Professor, Department of Architecture, Higher Institute of Engineering, El-Shorouk Academy, El-Shorouk City 11937, Egypt, omnia.shawky@sha.edu.eg-

Abstract:

Hot arid and desert regions like the MENA, Middle East and North Africa, regions are characterized by high levels of solar radiation and high temperatures. Incoming solar radiation on buildings affect the thermal ad visual comfort of building occupants. Large glazed buildings allow solar radiation to get inside the building enhancing visual comfort, but also it affects thermal comfort and causes glare.

The building envelope is the main mediator between the outdoor environment and solar radiation and the indoor of buildings in terms of visual and thermal comfort. Climate change resulted in excessive solar radiation which affects thermal and visual comfort in buildings. While solar radiation is considered a potential as renewable energy source, it is now a great challenge to be controlled inside buildings. Daylight can be optimized by different strategies in order to achieve thermal and visual comfort in buildings. This paper presents a study of how to achieve thermal comfort in hot arid climates using an Artificial Intelligence AI-controlled shading system. The proposed AI- controlled shading is applied to an office building in Egypt to check the reduction in energy consumption and enhancement in thermal comfort. This study concluded that the proposed AI- controlled shading system dropped the indoor temperature by 4°C and reduced energy consumption by 25% while thermal comfort complaints decreased by 77.78% and glare difficulties by 76%.

Background

Hot arid regions, such as the MENA (Middle East and North Africa), experience high levels of solar radiation and temperatures. Buildings in these regions, particularly those with large glazed surfaces, face challenges related to maintaining thermal and visual comfort for occupants. Traditional shading solutions often fail to adapt dynamically to changing environmental conditions, leading to issues like excessive heat gain, glare, and high energy consumption for cooling.

Problem The main problem addressed in this paper is the difficulty of achieving indoor thermal comfort in office buildings located in hot arid climates without incurring high energy costs. Conventional shading devices, whether manual or automated, are often insufficient due to their lack of adaptability to the dynamic nature of solar radiation and glare.

Objectives Investigate the impact of AI-controlled shading devices on indoor thermal comfort. Evaluate the potential energy savings from implementing AI-controlled shading in office buildings. Enhance thermal and visual comfort for building occupants through adaptive shading solutions. Provide a case study analysis in an office building in Egypt to demonstrate AI-controlled shading devices

Significance The study aims to provide a sustainable solution for improving indoor thermal comfort while reducing energy consumption in hot arid climates. By leveraging AI, the proposed shading system can dynamically adjust to environmental changes, thus optimizing energy use and enhancing occupant comfort. This has significant implications for achieving energy-efficient building designs in regions with harsh climates.

Methodology The research employs a deductive approach using both qualitative and quantitative methods: Case Study: An office building in New Cairo, Egypt, is selected for the case study. AI-Controlled Shading System: Development and implementation using Python programming and machine learning libraries such as Pandas, Scikit-Learn, TensorFlow, and Keras. Data Collection: Sensors are used to gather real-time data on temperature, occupancy, and solar radiation. Model Training: Machine learning models, including LSTM (Long Short-Term Memory) networks, are trained to predict optimal shading adjustments. Performance Monitoring: Continuous assessment of the system's impact on indoor temperature, energy consumption, and occupant comfort.

Results The implementation of the AI-controlled shading system in the case study building yielded significant improvements: Indoor Temperature: Reduced by 4°C on average. Energy Consumption: Decreased by 25%, saving 100,000 kWh annually. Occupant Complaints: Thermal comfort complaints reduced by 77.78%, and glare issues decreased by 76%.

Keywords:

Thermal Comfort, Hot Arid Climate, Shading Device, AI-Controlled Shading

References:

1- Gianpiero Evola, Federica Gullo, Luigi Marletta “The role of shading devices to improve thermal and visual comfort in existing glazed buildings”, Energy Procedia, Volume 134, 2017, Pages 346-355, ISSN 1876-6102,https://doi.org/10.1016/j.egypro.2017.09.543.

2- Awad, Jihad & Abd-Rabo, Lamia. (2020). Daylight and Energy Performance Optimization in Hot - Arid

Regions: application and adaptation guide for designers in the UAE. Procedia Manufacturing. 44. 237-244. 10.1016/j.promfg.2020.02.227.

3- Anber, M. (2024) The Efficiency of Using Mineral Insulating Solutions in Buildings in Egypt, International Design Journal, Volume 14_Issue 1_Pages 371-379. DOI: 10.21608/idj.2023.249201.1099
4- K.A. Cort, J.A. McIntosh, G.P. Sullivan, T.A. Ashley, C.E. Metzger, N. Fernandez, (2018) Testing the Performance and Dynamic Control of Energy-Efficient Cellular Shades in the PNNL Lab Homes [Online], Office of Scientific and Technical Information (OSTI), https://doi.org/10.2172/1477792.
5- C. Shum & L. Zhong (2023) A review of smart solar shading systems and their applications: Opportunities in cold climate zones, Journal of Building Engineering 64 (2023) 105583, ELSEVIER.
6- Alwetaishi M., Al-Khatri H., Benjeddou O., Shamseldin A., Alsehli M., Alghamdi S., Shrahily R., (2021). An investigation of shading devices in a hot region: A case study in a school building, Ain Shams Engineering Journal, Volume 12, Issue 3, pp. 3229-3239, ISSN 2090-4479, https://doi.org/10.1016/j.asej.2021.02.008.
7- Dev, G.; Saifudeen, A.; Sathish, A. (2021) Facade control systems for optimal daylighting: A case of Kerala. IOP Conf. Ser. Earth Environ. Sci. 2021, 850, 012014.
8- Joshi, Neha & Patki, Pradnya. (2022). Relationship of shading devices and its effects on daylight in Commercial buildings in Pune. IOP Conference Series: Earth and Environmental Science. 1084. 012079. 10.1088/1755-1315/1084/1/012079.
9- A Nocente et al (2021) Comparative field tests of an electrochromic shading device - thermal and visual comfort . J. Phys.: Conf. Ser. 2069 012222. doi:10.1088/1742-6596/2069/1/012222
10- Hoof, Joost & Mazej, Mitja & Hensen, Jan. (2010). Thermal comfort: Research and practice. Frontiers in Bioscience. 15. 765-788. 10.2741/3645.
11- Asim Ahmad, Om Prakash, Anil Kumar, S.M. Mozammil Hasnain, Puneet Verma, Ali Zare, Gaurav Dwivedi, Anukul Pandey, "Dynamic analysis of daylight factor, thermal comfort and energy performance under clear sky conditions for building: An experimental validation", Materials Science for Energy Technologies,Volume 5,2022,Pages 52-65,ISSN 2589-2991, https://doi.org/10.1016/j.mset.2021.11.003.
12- Ruck, N. & Aschehoug, Øyvind & Aydinli, Samil & Christoffersen, Jens & Edmonds, Ian & Jakobiak, Roman & Kischkoweit-Lopin, M. & Klinger, M. & Lee, Eleanor & Courret, Gilles & Michel, L. & Scartezzini, Jean-Louis & Selkowitz, Stephen. (2000). Daylight in Buildings - A source book on daylighting systems and components.
13- Selkowitz, Stephen & Aschehoug, Øyvind & Lee, Eleanor (2003). Advanced Interactive Facades - Critical Elements for Future GreenBuildings?. the annual USGBC International Conference and Expo, November 2003. LBNL-53876.
14- A. W. &. Fatma Fathy, "A parametric approach for achieving optimum daylighting performance through solar screens in desert climates," Journal of Building Engineering, vol. 3, pp. 155-170, 2015.
15- W. P. &. A. M. A. Jianxin Hu, "Using diva for assessing climate-based leed daylight credit," in The 43rd Annual National Solar Conference, 2014.
16- Gugliermetti, F. & Bisegna, Fabio. (2005). Static and dynamic daylight control systems: Shading devices and electrochromic windows. IBPSA 2005 - International Building Performance Simulation Association 2005.
17- Galal, Omar & Sailor, David & Mahmoud, Hatem. (2020). The impact of urban form on outdoor thermal comfort in hot arid environments during daylight hours, case study: New Aswan. Building and Environment. 184. 107222. 10.1016/j.buildenv.2020.107222.
18- V. Costanzo, R. Yao, E. Essah, L. Shao, M. Shahrestani, A.C. Oliveira, M. Araz, A. Hepbasli, E. Biyik, "A method of strategic evaluation of energy performance of Building Integrated Photovoltaic in the urban context", Journal of Cleaner Production, Volume 184,2018, Pages 82-91, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2018.02.139.
19- Maria Konstantoglou, Aris Tsangrassoulis, (2016) Dynamic operation of daylighting and shading systems: a literature review, Renew. Sustain. Energy Rev. 60, 268–283.
20- Luo, Z., Sun, C., Dong, Q., & Yu, J. (2021). An innovative shading controller for blinds in an open-plan office using machine learning. Building and Environment, 189, 107529. doi:10.1016/j.buildenv.2020.10752

Paper History:

Paper received July 01, 2024, Accepted August 18, 2024, Published on line November 1, 2024.

