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論　文　要　旨
Thesis Abstract

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主論文題名　（Title）

Artificial Intelligence Applications in Sustainable Infrastructure: Solar Photovoltaic Inspection and Estimation of Indoor Environmental Variables in a Smart Building

内容の要旨　（Abstract）

The global surge in urbanization and technological advancements underscores the crucial intersection of renewable energy and sustainable infrastructure. As society becomes increasingly urban-centric, ensuring optimal indoor comfort and promoting energy-efficient solutions have become paramount. The rising demand for renewable energy sources, such as solar photovoltaic (PV) systems, alongside the need for effective and sustainable infrastructure management, presents both challenges and opportunities.

The proliferation of solar PV systems to meet the world's renewable energy demand is accompanied by significant challenges. During their lifecycle, PV panels can acquire defects, diminishing their efficiency and lifespan. Current inspection methods, while effective, are limited in scope and speed. Our research delves into the comparative efficacy of thermal infrared (IR) and electroluminescence (EL) imaging for PV inspection. Given the high cost of commercial EL cameras, a novel, cost-effective EL imaging approach was proposed using a modified Panasonic GF3 camera. Results highlight EL imaging's superior ability to detect a gamut of solar cell defects, providing a cost-effective and efficient solution for both small and medium scale PV installations.

Artificial intelligence (AI) tools, which are fast, robust, and adaptive can overcome the drawbacks of traditional solutions for several power systems problems. In this work, applications of AI techniques have been studied for solving two important problems in sustainable infrastructure. Building upon the potential of EL imaging, the study further introduces a deep learning-based methodology for the automated detection of defective solar cells. By employing convolutional neural network (CNN) architectures, including a

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fine-tuned VGG16 model, we achieved a breakthrough 95.2% accuracy in defect detection.

Additionally, to facilitate real-time interaction and visualization of the trained models, a web application was developed for practical, real-world testing. This AI-driven approach promises a revolution in PV quality inspection, enabling more consistent, rapid, and precise evaluations, thereby boosting overall solar PV performance.

Simultaneously, as urban populations swell, especially in metropolises like Tokyo, the onus to develop energy-efficient, occupant-friendly buildings becomes even more pressing. Here, smart buildings, equipped with an array of sensors and advanced software, including AI algorithms, take center stage. However, there is a prevailing challenge of over-reliance on extensive sensor networks, which are costly and complex to maintain. Addressing this challenge, this thesis introduces an innovative methodology using extreme gradient boost (XGBoost) models. Leveraging limited data, these models accurately estimate vital indoor environmental variables such as temperature, relative humidity, and carbon dioxide (CO_2) concentrations with an average root mean squared error (RMSE) of 0.3°C, 2.6%, and 26.25 ppm, respectively. The result is a threefold benefit: a reduction in the need for pervasive sensors, an enhancement in heating ventilation and air conditioning (HVAC) system efficiency, and occupant comfort.

In conclusion, this thesis explores the vast potential of AI applications within renewable energy and sustainable infrastructure domains. Through innovative methodologies for solar PV inspection and smart building management, it sets a robust foundation for future endeavors, aiming to shape a sustainable and energy-efficient urban landscape.

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