Remote Sensing Building Envelope Inspection Robots with Indoor Environmental Quality (IEQ) Awareness

Prime Recipient: Carnegie Mellon University, Center for Building Performance and Diagnostics, Department of Civil and Environmental Engineering
**Team Leader:** Erica Cochran Hameen, Ph.D., and Pingbo Tang, Ph.D., P.E. (Co-PI) **Team Member**: Pengkun Liu, Ruoxin Xiong and Wei Liang
Partners: Green Building Alliance, Regional Industry Development Corporation, Nexii Building Solutions

Project Summary: Remote Sensing Building Envelope Inspection Robots with IEQ Awareness project will provide a cost-effective, cyber-secure, and replicable solution to create a collaborative framework using an automatic mobile sensing platform with IEQ sensors combined with thermal and visual camera and drones to conduct building envelope fault detection and identify IEQ problems caused by building envelope defects. The proposed system of Remote Sensing Platform with IEQ Awareness will aggregate innovations to achieve a significant cost reduction when compared to conventional building envelope inspection and mapping methods and have a positive impact on building energy efficiency and occupancy health and productivity.

Key Takeaway:

- A system that surveys relationship between building envelope and IEQ problems; equipped with a variety of IEQ sensors
- Validation and development on both commercial and residential development sites in Southwestern PA
- Collaborative framework between indoor robots and outdoor drones with machine learning-aided infrared thermography
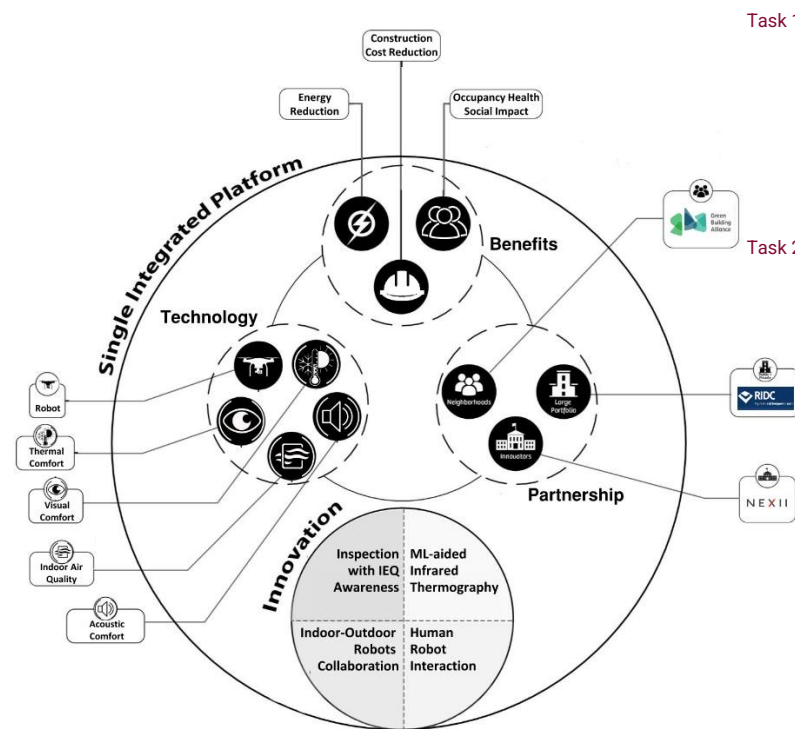
Task 1 — **Development of Outdoor-Indoor Building Inspection Robots with IEQ awareness**

Sub-Task 1.1: *Development of Indoor Remote Sensing Robot with IEQ Awareness*

Sub-Task 1.2: *Development of Outdoor UAV Remote Sensing Robot*

Task 2 — **Testing and building assessment in real world conditions**

Sub-Task 2.1: *Remote Infrared Thermography for Building Envelope Fault Detection with Computer Vision Aided Calibration*

Sub-Task 2.2: *Building Envelope Insulation Assessment and Defect Detection by Indoor-Outdoor Robots Collaboration*

Sub-Task 2.3: *Non-Invasive Air-tightness Detection using IEQ Remote Sensing Robot and Infrared Thermographic Camera*

Sub-Task 2.4: *Thermal Anomaly Mapping and Detection*

Sub-Task 2.5: *4D Phasing problem of retrofit that need parallel inspection and installation activities*

Proposed Improvement Goals:

- >50% cost reduction when compared to the current state of the art
- Provide energy usage reduction by identification of thermal bridges, air leakages, and corrosions of building envelopes.

Project's Impact:

Cost effective, replicable, and scalable solutions for US communities and 124 million buildings investing millions in building retrofits and holds the potential to achieve a significant cost reduction when compared to conventional building envelope inspection and mapping methods and have a positive impact on building energy efficiency and occupancy health and productivity.