A BIM-based and data-driven approach for comprehensive façade inspection guidance in cities

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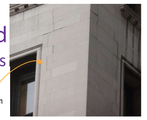
BI LAB

Challenges in façade inspection

Guideline: Material based

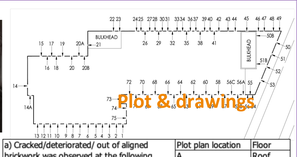
E.g., Crack in stones



What To Look For:
Location, size and direction of crack. Condition of mortar in joints. Support system for stone. Rust stains.

Practice: Component based

E.g., Coating corrosion at window lintel



a) Cracked/deteriorated/ out of aligned brickwork was observed at the following location:	Plot plan location	Floor
	A	Roof
	10	2
	68	1
	70	1

b) Rusted lintels were observed throughout the building. Typical of the condition, but not an exhaustive list are the following locations:	1	4, 5, 6,7
	12, 13	6
	14	7
	15	4
	50	4
	...	...

Unstructured descriptions

Manual and visual inspection: Inconsistent inspection and wide range of omissions

Conflict in guidelines vs. practice Material-based vs. Component-based

Scattered documentations failed to provide a holistic understanding

Contributions

- Taxonomies for façade component hierarchies and defect types, and the mapping relationships between the two.
- Spatial analysis of defect patterns in NYC neighborhoods.
- A façade safety inspection domain ontology and reasoning mechanisms for model-based inspection checklist generation.
- Integrated visualization techniques in improving inspectors' understanding of façade conditions.

Publications

Shi, Z., *Park, K, and Ergan, S. (2024). A Taxonomy of Urban Façade Defects and Their Distribution on Façade Components: A Data-driven Analysis of Historical Inspection Reports . JCEM (under 2nd round review)*

Shi, Z.*, and Ergan, S. (2024). Design and evaluation of visualization techniques to facilitate urban façade inspection. Proceedings of i3CE, July 28-31, 2024, Pittsburg, PA.*

Shi, Z., *Lee, Y. and Ergan, S. (2023). Model-based checklist generation for façade safety inspection guidance. Proceedings of i3CE, June 25-28, 2023, Corvallis, Oregon.*

Shi, Z. *and Ergan, S (2021). An ontology towards BIM-based guidance of building façade maintenance. Proceedings of the 38th ISARC, November 2-3, Dubai, UAE.*

Shi, Z., *Park, K., Ergan, S (2020). Towards a comprehensive façade inspection process: An NLP-based analysis of historical façade inspection reports for knowledge discovery. Proceedings of the 37th ISARC, October 27-28, Kitakyushu, Japan.*

Shi, Z., *Ergan, S. (2020). Towards Point Cloud and Model-Based Urban Façade Inspection: Challenges in the Urban Façade Inspection Process. In Construction Research Congress 2020: Safety, Workforce, and Education (pp. 385-394).*

Shi, Z., *Ergan, S. (2018). Leveraging point cloud data for detecting building façade deteriorations caused by neighboring construction. Tamap Journal of Engineering, 2018.0*

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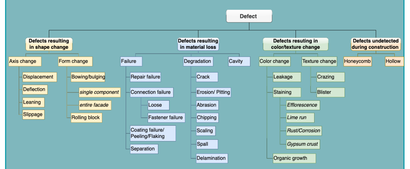
Identify characteristics of façade inspection information requirements → Identify building groups, façade defect patterns, and spatial distribution → Generate a customized checklist based on the BIM of a target building → Visualize façade condition data with integrated views

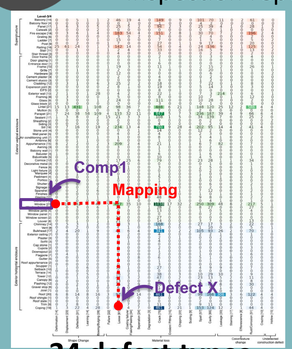
Literatures, guideline, glossaries, etc.

Define taxonomies



Define relationships

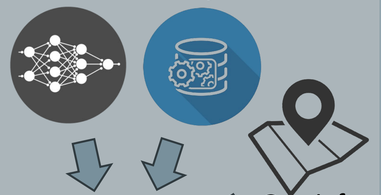
NLP based analysis of historical inspection reports



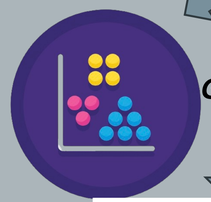
34 defect types

Inspection reports

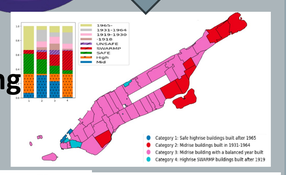
Building dataset



Geo-info

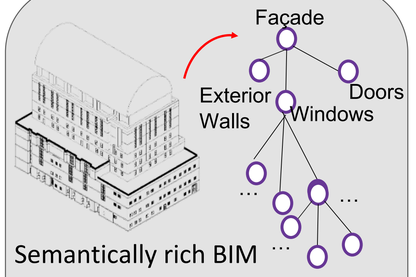


Geo-spatial analysis



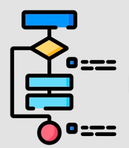
4 Building groups

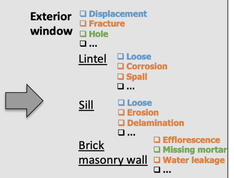
Defect patterns



Semantically rich BIM

Taxonomy of defects + **Defect – Component mappings**

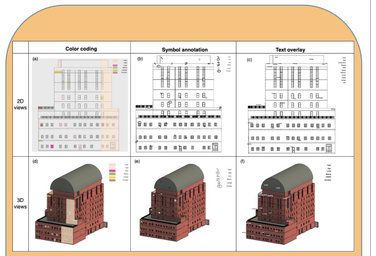




ChecklistGenerator

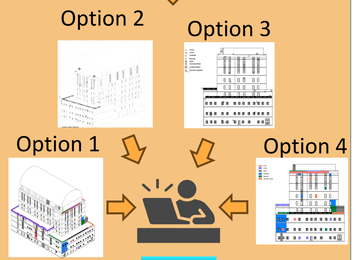
Building ID	Major façade material	Unique façade features showcased	Street facing ?	Inspection form
1	Brick masonry	Balcony, Balcony floor, Railings, Coping, Parapet, Entrance door, etc.	N	H
2	Concrete	Storefront, Door glazing, Window frame, Door frame, Signage, Light fixture, Window panel, etc.	Y	V
3	Brick masonry	Fire escape, Lintel, Sill, Air conditioning Unit, Decorative metal, Chimney, etc.	Y	V

Precision: 82%
Recall: 100%



Low-fidelity prototypes

Identify inspectors' preferences



Time reduction: 44.8%
Accuracy improvement: ~10%

Ref: Yang, X., & Ergan, S. (2014). Evaluation of visualization techniques for use by facility operators during monitoring tasks. Automation in Construction, 44, 103-118.